Coherent Configuration and Operation of Building Traffic Systems

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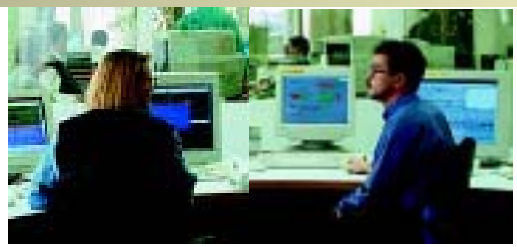
Building Life-Cycle Optimization

Life Cycle

Strategies & Plans

Design



Operations

Service Provision: Life-cycle Performance Optimization

Infrastructure: Interoperability

Emergency & Threats

Managed Systems & Crowds

Repertoire of Technology & Knowledge

Configuration and Operation Phases

- Configuration Phase
  - Specify requirements
  - Minimize capital and expected operating costs
  - Facilitate operational performance
- Operations Phase
  - Specify modes of operations
  - Optimize normal and emergency performance
  - Satisfy constraints

→ Nested and coherent performance guarantee

Outline

- Challenges for Coherence
- Coherent Performance Guarantee and Optimization
- Egress by Elevator Group
- Technology Roadmap

Challenges to Coherence

- Gaps between Phases
  - Scopes
  - Resolutions
  - Interdependencies
- Multiple Modes and Graceful Degradation
  - Normal mode: Economy and efficiency
  - Emergency mode: Life & property saving
  - Multiple criterion in one mode
  - Graceful degradation in mode shifting

Challenges to Coherence (Cont.)

- Subsystem and Model Diversity
  - Building traffic systems
  - HVAC
  - Occupant/pedestrian movements
  - Management/emergency responder team
- Solver Diversity

→Need design methodology for coherence across phases, models, and solutions along the resolution and mode axes

Methodology: Formal Semantics

- Common Specification of Properties
  - Extract properties of basic models and solvers
  - Derive composite properties

phase(config)

objective = Minimize CapitalCost

constraint={AvgServT < t1, SafeThruPut_Dn > Tr1}

mode(normal)

objective = Minimize AvgServT

constraint = { AvgServT < t1, AvgEnergy < e1}

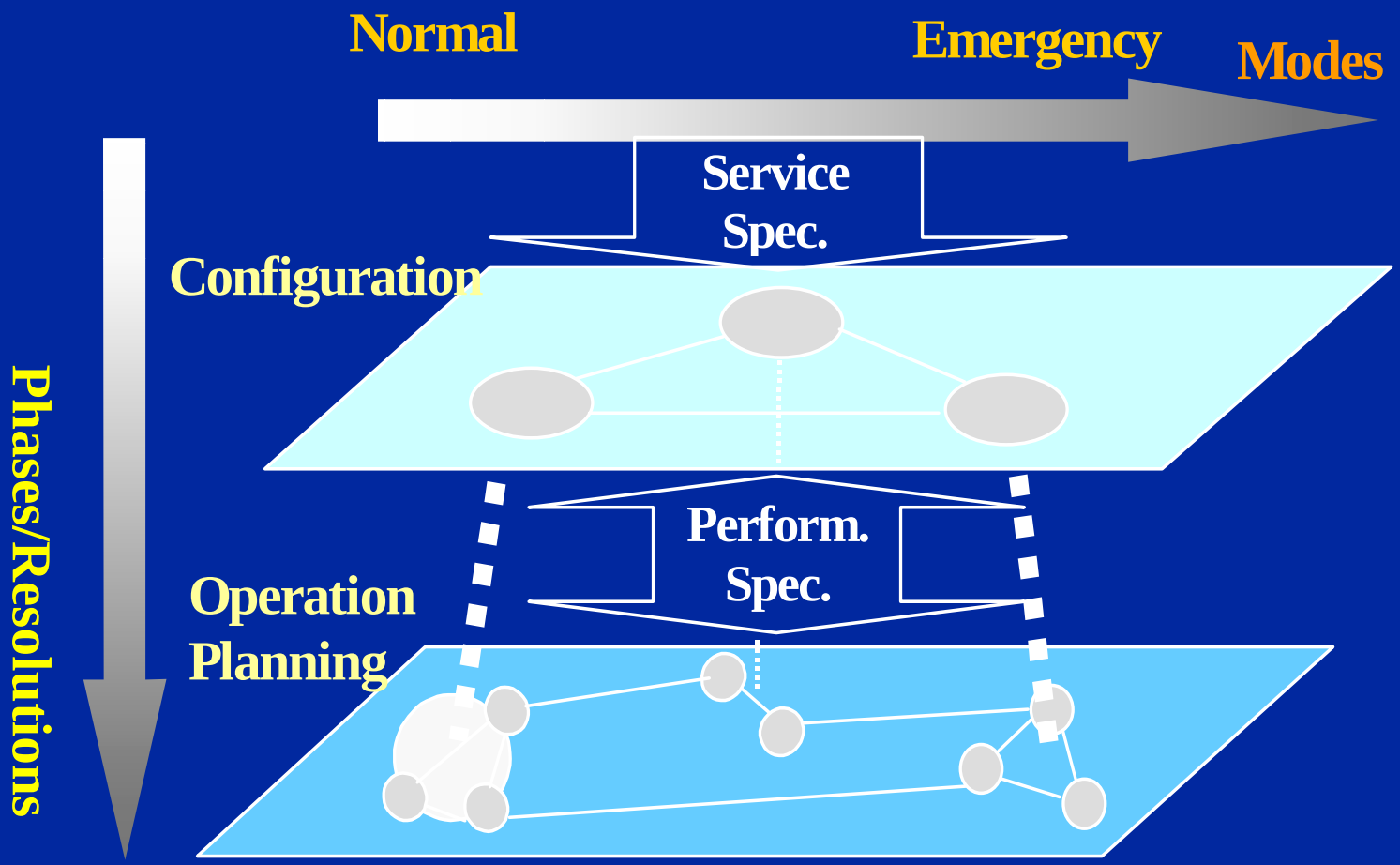
mode(emergency)

objective= Minimize[casualty,time(evac)]

constraint = { SafeThruPut_Dn > Tr1 }

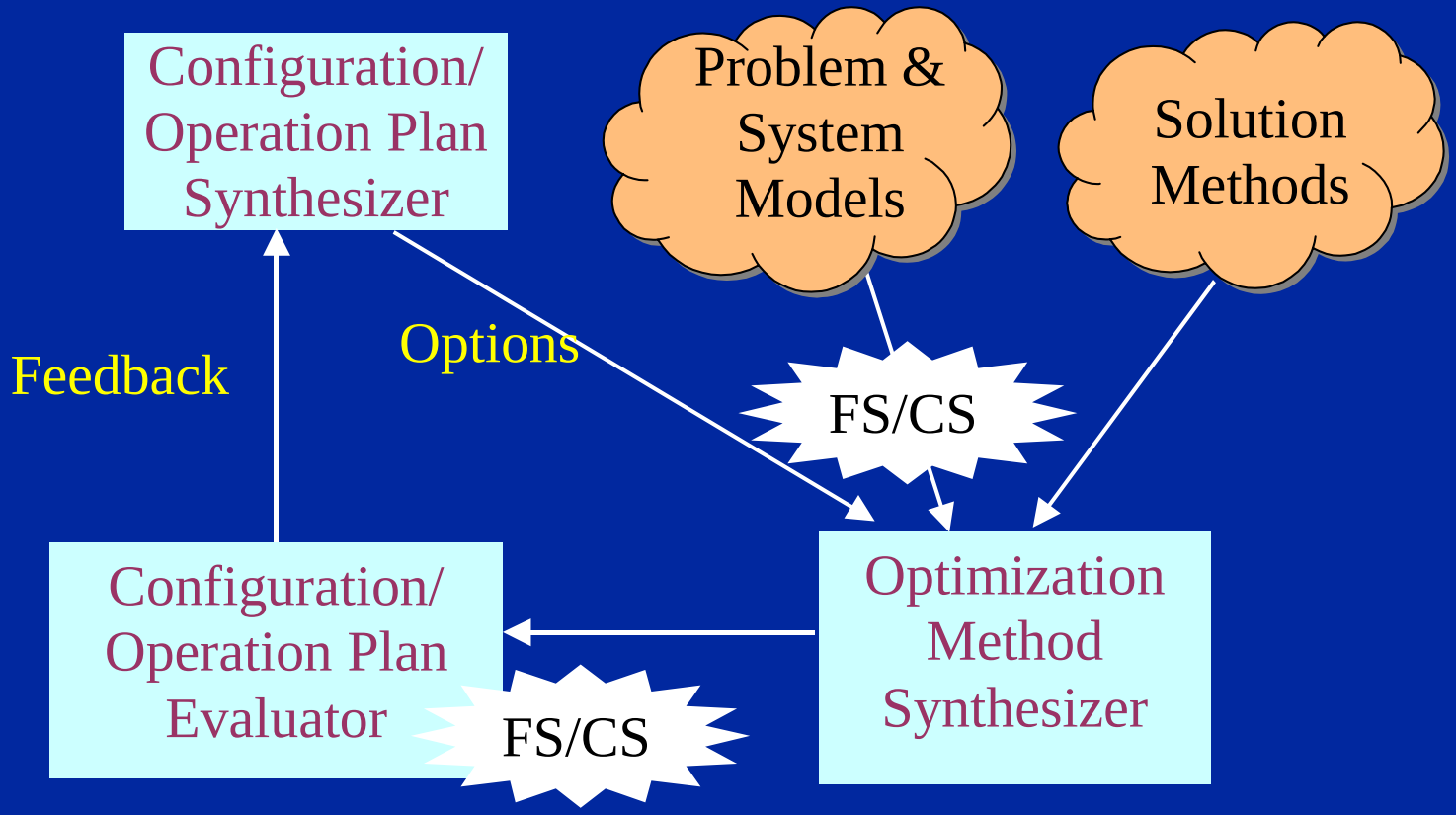
Methodology: Coherent Models

- Coherence: Semantic property constraint satisfaction



Methodology: Coherent Solutions

- Coherent Decomposition and Coordination
- Synthesis of Optimization Methods



Elevator Group Example

- Configuration and Operation Input
  - Building, HVAC, elevator group and egress route configurations
  - Modes and objectives
  - Passenger traffic patterns
  - Single-car operation rules

→ Coherent synthesis of group dispatching

→ Efficient performance estimation for configuration

(e.g., AvgServTime, SafeThruPut_Dn)

Coherent Modeling

- Two-tier: Group and individual cars
- Coherent Objective and Interface Constraint

Minimize Average Service Time (AST)

Passenger Assignment

Subject to

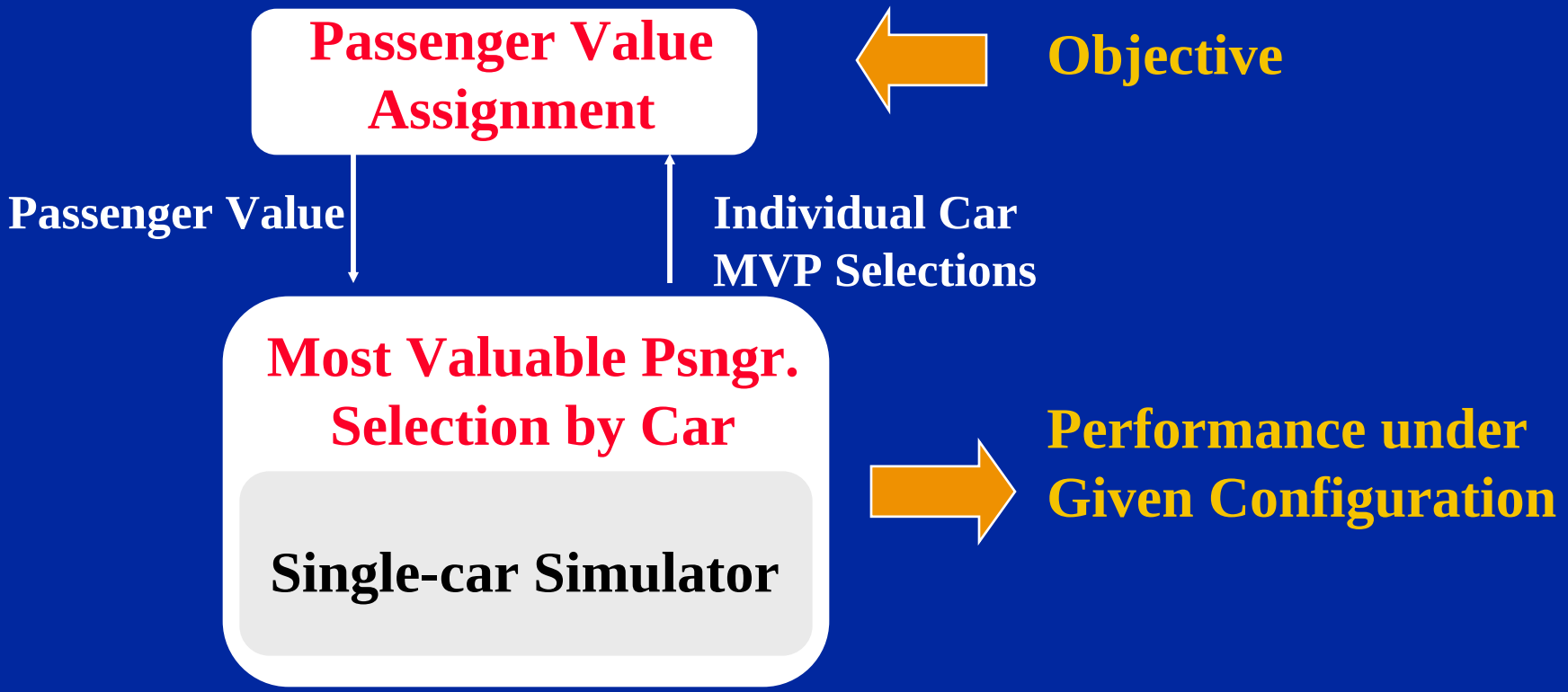
One-Passenger-to-One-Car Constraint

Simulation Model of Single-Car Dispatching

Car Movement Dynamics	**Building Configuration**
Single-Car Dispatching (AST by Car)	**Car Capacity and Operation Constraints**

Coherent Solvers

- Price-based Coordination of Car Dispatching



Evaluation of Configuration - Normal Mode

- Given 4 cars, 10 floors, 100 passengers and Single-car Dispatching Rule
- Capable of Computing Solutions for Various Traffic Modes

Scenario	Uppeak	Downpeak	Two-way
Avg. Service Time	30.84	54.44	45.43
CPU time(Secs.)	98	127	180

→Efficient estimation

AST(Config., Op_Policy, normal mode)

Application to Emergency Egress

- Objective: Minimum Evacuation Time (ET)
- Operation Policy
  - Egress routing
  - Coordination with HVAC for egress ventilation
  - Coordination of occupant arrivals (down-peak)
  - Elevator allocation:

    emergency responder lift & occupant evacuation

→ Application of the coherent solver

→ Efficient performance estimation

ET (Config., Op_Policy, Emerg. mode)

SafeThruPut_Dn

Roadmap

Goal

Coherent Configuration & Operation

Building Performance Optimization

Semantic Information Model

Infra-structural Inter-operability

(Current)

Performance Evaluator	Optimization Method Synthesizer
Coherence Check/Constraint Programming	
Formal Semantic Specification	
Configuration & Operation Solver Libraries	**Configuration & Operation Model Libraries**	**Crowd Behavior/ Expert Decsion Model Libraries**

Data, Information and Process Integration